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**Law Group**  
Air Products and Chemicals, Inc.  
7201 Hamilton Boulevard  
Allentown, Pennsylvania 18195-1501  
U.S.A.

**To:** Examiner Sara Clarke  
**Company:** United States Patent and Trademark Office  
Art Unit 3743

**Phone:**  
**Fax:** (703) 746-4956

**From:** Keith D. Gourley  
**Department:** Law Group - Patent Dept.  
**Phone:** 610-481-6566  
**Fax:** 610-481-7083

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**Transmission Message:**

**Our Docket No.:** 06204P USA  
**In Re Application:** Mahendra Ladharam Joshi  
**Serial No.:** 10/067,450  
**Filed:** February 5, 2002  
**Group Art Unit:** 3743  
**Examiner:** Clarke, Sara Sachie  
**For:** Ultra Low NOx Burner for Process Heating

**Included Documents:**  
Amendments to the Claims

Attached is a listing of claims which will replace all prior versions and listing of claims.

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Patent: 06204P USA

## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appl. No. : 10/067,450 : Confirmation No.: 7386  
Applicant : Mahendra Ladharam Joshi  
Filed : February 5, 2002  
For : Ultra Low NOx Burner for Process Heating  
Art Unit : 3743  
Examiner : Clarke, Sara Sachie  
  
Docket No. : 06204P USA  
Customer No. : 23543

**Amendments to the Claims:**

This listing of claims will replace all prior versions and listings of claims in the subject patent application.

Claim 1 (canceled).

Claim 2 (currently amended). An ultra low NOx burner for process heating, comprising:

- a) a fluid based flame stabilizer which can provide a fuel-lean flame at equivalence ratio in the range of  $\phi = 0.05$  to  $\phi = 0.3$ ; and
- b) a plurality of fuel staging lances surrounding said flame stabilizer, each said lance comprising a pipe having a staging nozzle at a firing end thereof, each lance having at least one hole for staging fuel injection. ~~The ultra-low NOx burner for process heating of claim 1,~~ each hole having a radial divergence angle and an axial divergence angle wherein said at least one hole and said divergence angles are adapted to provide complete circumferential coverage of the fuel-lean flame;

whereby NOx emissions of less than 9 ppmv are generated at near stoichiometry conditions.

Claim 3 (currently amended). An ultra low NOx burner for process heating, comprising:

- a) a fluid based flame stabilizer which can provide a fuel-lean flame at equivalence ratio in the range of  $\phi = 0.05$  to  $\phi = 0.3$ ; and
- b) a plurality of fuel staging lances surrounding said flame stabilizer, each said lance comprising a pipe having a staging nozzle at a firing end thereof, each lance having at least one hole for staging fuel injection. The ultra-low-NOx burner for process heating of claim 1, each hole having a radial divergence angle and an axial divergence angle wherein said at least one hole and said divergence angles are adapted to provide a flat flame pattern;

whereby NOx emissions of less than 9 ppmv are generated at near stoichiometry conditions.

Claim 4 (currently amended). An ultra low NOx burner for process heating, comprising:

- a) a fluid based flame stabilizer which can provide a fuel-lean flame at equivalence ratio in the range of  $\phi = 0.05$  to  $\phi = 0.3$ ; and
- b) a plurality of fuel staging lances surrounding said flame stabilizer, each said lance comprising a pipe having a staging nozzle at a firing end thereof, each lance having at least one hole for staging fuel injection. The ultra-low-NOx burner for process heating of claim 1, each hole having a radial divergence angle and an axial divergence angle wherein said at least one hole and said divergence angles are adapted to provide a load shaping flame pattern;

whereby NOx emissions of less than 9 ppmv are generated at near stoichiometry conditions.

Claim 5 (currently amended). The ultra low NOx burner for process heating of claim 4 claims 2, 3 or 4, wherein the plurality of fuel staging lances comprises between 4 and 16 staging lances per flame stabilizer.

Claim 6 (currently amended). The ultra low NOx burner for process heating of claim 4 claims 2, 3 or 4, wherein each staging nozzle has between 1 hole and 4 holes.

Claim 7 (currently amended). The ultra low NOx burner for process heating of claim 4 claims 2, 3 or 4, wherein the radial divergence angle is between  $8^\circ$  and  $24^\circ$ .

Claim 8 (currently amended). The ultra low NOx burner for process heating of ~~claim 1~~ claims 2, 3 or 4, wherein the axial divergence angle is between 4° and 16°.

Claim 9 (currently amended). The ultra low NOx burner for process heating of ~~claim 1~~ claims 2, 3 or 4, wherein the nozzle is adapted to allow fuel to exit the nozzle at from 300 to 900 feet per second for natural gas staging fuel.

Claim 10 (currently amended). The ultra low NOx burner for process heating of ~~claim 1~~ claims 2, 3 or 4, wherein the fluid based flame stabilizer is a large scale vortex device.

Claim 11 (currently amended). The ultra low NOx burner for process heating of ~~claim 1~~ claims 2, 3 or 4, wherein the ~~large scale vortex device~~ ultra low NOx burner is adapted to provide a fuel-lean flame that has a peak flame temperature of less than approximately 2000° Fahrenheit.

Claim 12 (currently amended). The ultra low NOx burner for process heating of ~~claim 1~~ claims 2, 3 or 4, wherein the equivalence ratio is in the range of  $\phi = 0.05$  to  $\phi = 0.1$ .

Claim 13 (currently amended). The ultra low NOx burner for process heating of ~~claim 1~~ claims 2, 3 or 4, wherein a distance from the forward end of the burner to a point where mixing of staging flame and flame stabilizer flame occurs is approximately 8 to 48 inches.

Claim 14 (currently amended). The ultra low NOx burner for process heating of ~~claim 1~~ claims 2, 3 or 4, wherein the fuel rate of the staging for natural gas fuel is from 70% to 95% of the total fuel firing rate of the burner.

Claim 15 (currently amended). The ultra low NOx burner for process heating of ~~claim 1~~ claims 2, 3 or 4, including a burner block coaxial to said flame stabilizer.

Claims 16-18 (canceled).

Claim 19 (currently amended). An ultra low NOx burner for process heating, comprising:

a) a fluid based flame stabilizer in the form of a large scale vortex device which can provide a fuel-lean flame at equivalence ratio in the range of  $\phi = 0.05$  to  $\phi = 0.3$ ; and

b) between 4 and 16 fuel staging lances per flame stabilizer adjacent to said flame stabilizer, each said lance comprising a pipe having a staging nozzle at a firing end thereof, each lance having between one and four holes for staging fuel injection, each hole having a radial divergence angle and an axial divergence angle ~~The ultra-low NOx burner for process heating of claim 18,~~ wherein the fuel staging lances surround said flame stabilizer and the at least one hole and the divergence angles are adapted to provide complete circumferential coverage of the fuel-lean flame for circular staging.; whereby NOx emissions of less than 9 ppmv are generated at near stoichiometry conditions.

Claim 20 (currently amended). An ultra low NOx burner for process heating, comprising:

a) a fluid based flame stabilizer in the form of a large scale vortex device which can provide a fuel-lean flame at equivalence ratio in the range of  $\phi = 0.05$  to  $\phi = 0.3$ ; and

b) between 4 and 16 fuel staging lances per flame stabilizer adjacent to said flame stabilizer, each said lance comprising a pipe having a staging nozzle at a firing end thereof, each lance having between one and four holes for staging fuel injection, each hole having a radial divergence angle and an axial divergence angle ~~The ultra-low NOx burner for process heating of claim 18,~~ wherein the fuel staging lances are positioned in a linear fashion in single or multiple rows on either side of the flame stabilizer and wherein the at least one hole and the divergence angles are adapted to provide a flat flame profile.; whereby NOx emissions of less than 9 ppmv are generated at near stoichiometry conditions.

Claim 21 (currently amended). An ultra low NOx burner for process heating, comprising:

a) a fluid based flame stabilizer in the form of a large scale vortex device which can provide a fuel-lean flame at equivalence ratio in the range of  $\phi = 0.05$  to  $\phi = 0.3$ ; and

b) between 4 and 16 fuel staging lances per flame stabilizer adjacent to said flame stabilizer, each said lance comprising a pipe having a staging nozzle at a firing end thereof, each lance having between one and four holes for staging fuel injection, each hole having a radial divergence angle and an axial divergence angle ~~The ultra low NOx burner for process heating of claim 18,~~ wherein the fuel staging lances are positioned in a linear fashion in single or multiple rows on either side of the flame stabilizer and wherein the at least one hole and the divergence angles are adapted to provide a flame confined between two parallel flat planes.

whereby NOx emissions of less than 9 ppmv are generated at near stoichiometry conditions.

Claim 22 (currently amended). The ultra low NOx burner for process heating of ~~claim 18~~ claims 19, 20 or 21, wherein the fuel staging lances are positioned in a geometrical fashion and almost parallel to a load geometry in a single or multiple rows and close to the flame stabilizer and wherein the at least one hole and the divergence angles are adapted to provide a flame confined between two parallel flat planes.

Claim 23 (currently amended). The ultra low NOx burner for process heating of ~~claim 18~~ claims 19, 20 or 21, wherein the radial divergence angle is between 8° and 24° and the axial divergence angle is between 4° and 16°.

Claim 24 (currently amended). The ultra low NOx burner for process heating of ~~claim 18~~ claims 19, 20 or 21, wherein the nozzle is adapted to allow fuel to exiting the nozzle at from 300 to 900 feet per second for natural gas staging fuel.

Claim 25 (currently amended). The ultra low NOx burner for process heating of ~~claim 18~~ claims 19, 20 or 21, wherein the large scale vortex device is adapted to provide a fuel-lean flame that has a peak flame temperature of less than approximately 2000° Fahrenheit.

Claim 26 (currently amended). The ultra low NOx burner for process heating of ~~claim 18~~ claims 19, 20 or 21, wherein the equivalence ratio is in the range of  $\phi = 0.05$  to  $\phi = 0.1$ .

Claim 27 (currently amended). The ultra low NOx burner for process heating of ~~claim 18-claims 19, 20 or 21~~, wherein a distance from the forward end of the fuel pipe of the flame stabilizer to a point where mixing of staging flame and flame stabilizer flame is approximately 8 to 48 inches.

Claim 28 (currently amended). The ultra low NOx burner for process heating of ~~claim 18-claims 19, 20 or 21~~, wherein the fuel rate of the staging for natural gas fuel is from 70% to 95% of the total fuel firing rate of the burner.

Claim 29 (currently amended). The ultra low NOx burner for process heating of ~~claim 18-claims 19, 20 or 21~~, including a burner block coaxial to said flame stabilizer.

Claims 30-31 (canceled).

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Claim 32 (currently amended). The ultra low NOx burner for process heating of ~~claim 18-claims 19, 20 or 21~~, wherein a separation distance between individual fuel lances are from about 2 to 12 inches.